FIG. 1
(PRIOR ART)

FIGURE 2

$$V_{piezo} = \frac{Q_{piezo}}{C_{piezo}}$$

FIGURE 3

Proposed New Milli–actuator Solution

FIGURE 4

Proposed New Milli-actuator Solution— Charge Mode

New 4 Bit DAC

4bit Offset DAC
1.12V to 2.92V range.
120mV steps
DAC Center is 2.08V.

5V Amp

VREF=2V

52.8k

5V Internal Reference

50k

10k

110k

DACM

3pF

G2Z G2Z
200k 100k

G1Z G2Z
50k

INP

INM

88k

1.24M

2uF

1X
1X

6.125X
6XN

6.125X
6XP

33nF

Csense

100

392

392

6XP

6XN

Cpiezo
(1nF to 14nF)
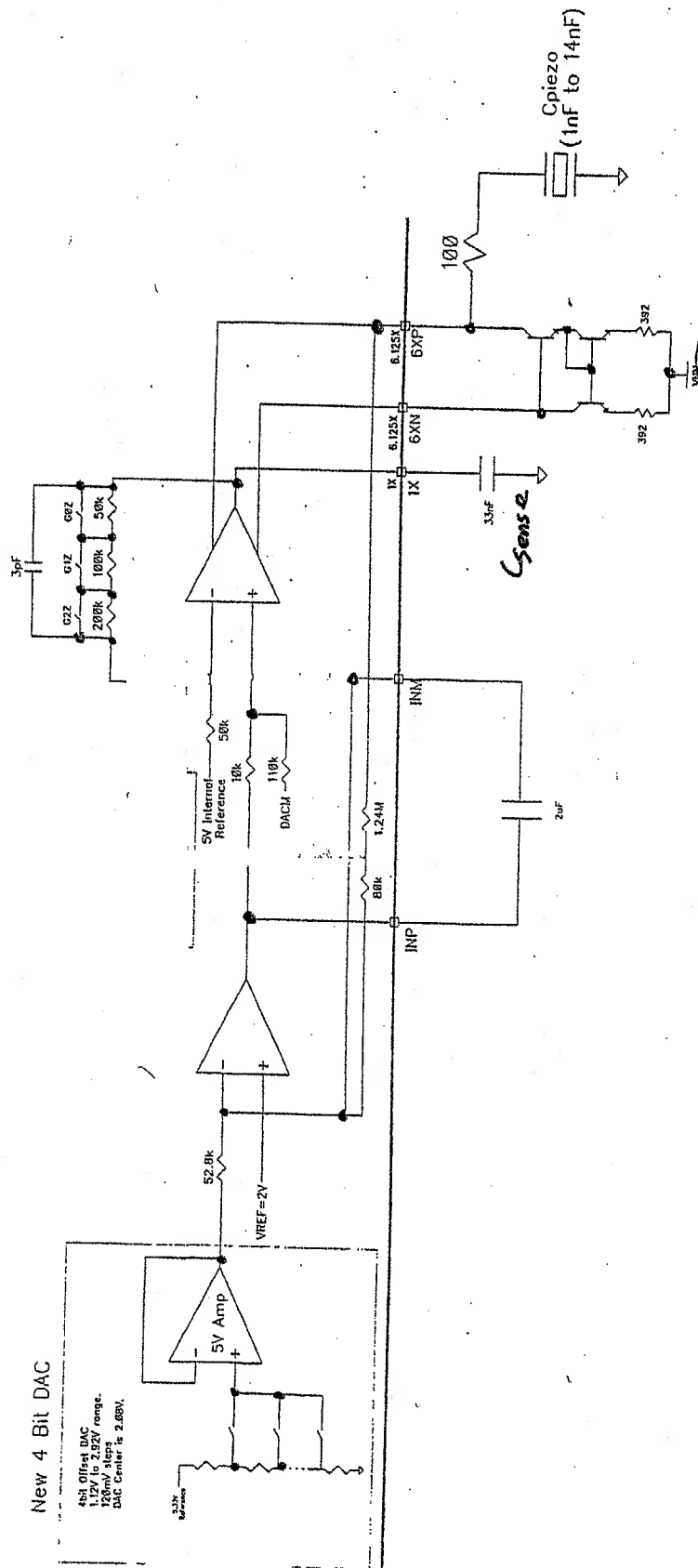
FIGURE 5

Proposed New Milli-actuator Solution – Voltage Mode

FIGURE 6

TRANSIENT Response

out 1

out by (three pieces)

395m 397m 399m 401m 403m 405m 407m 409m

30 20 10 0.0 10 20 30
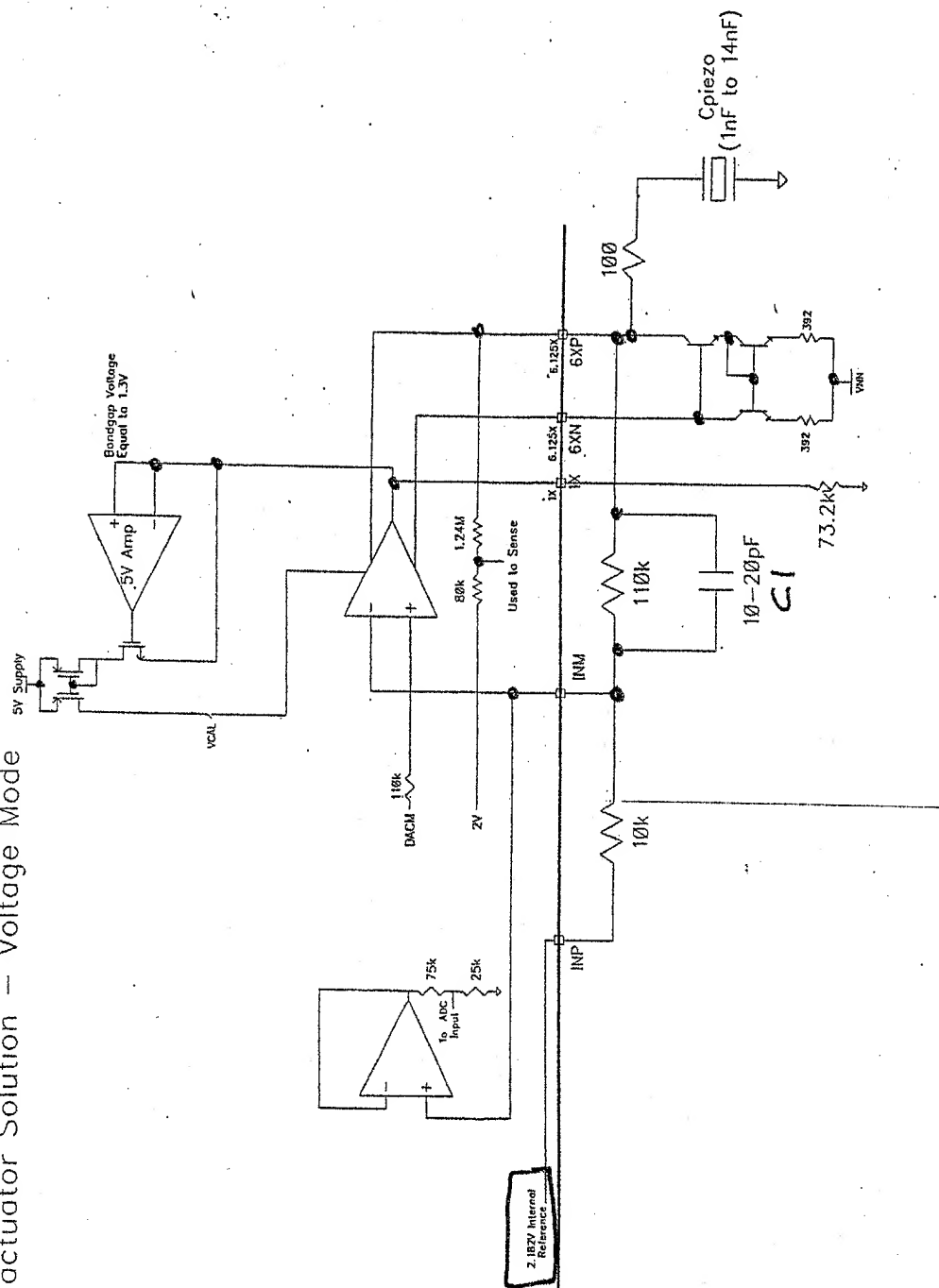
FIGURE 7

TRANSIENT Response

FIGURE 8

FIGURE 9

R_1, R_2 are resistors used in DC restore amplifier in charge mode

out6xn and out6xp are internally switched off $(I=0)$ and out6xp is high impedance. Piezo voltage is now sensed through R_1, R_2 divider and buffered and/or data converted to digital.

TO ADC

102

V_{ref} R_1 R_2

R_f

R_i

V_{ref}

DAC input

44

out6xn

out6xp

+HV

−HV

C_{piezo}
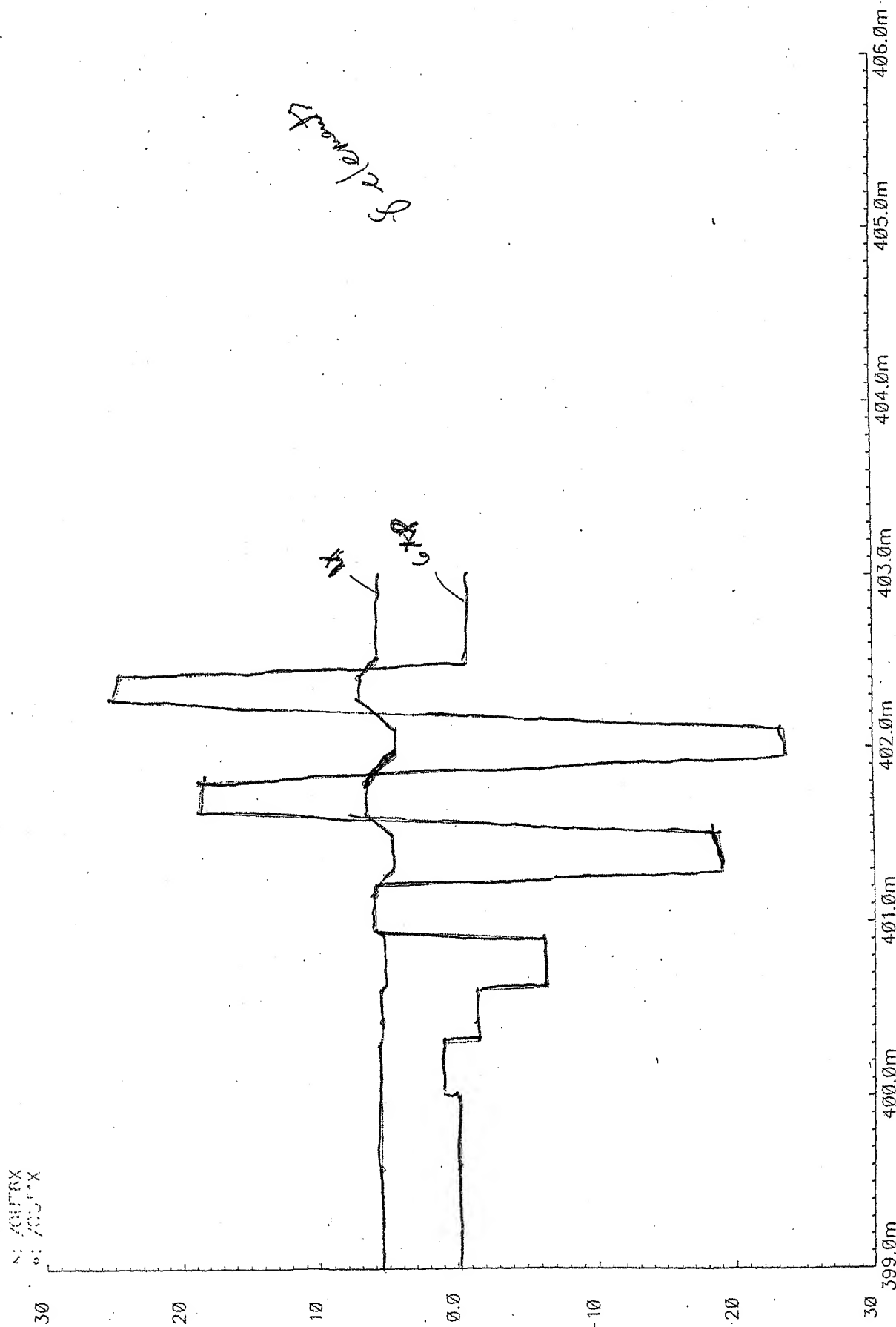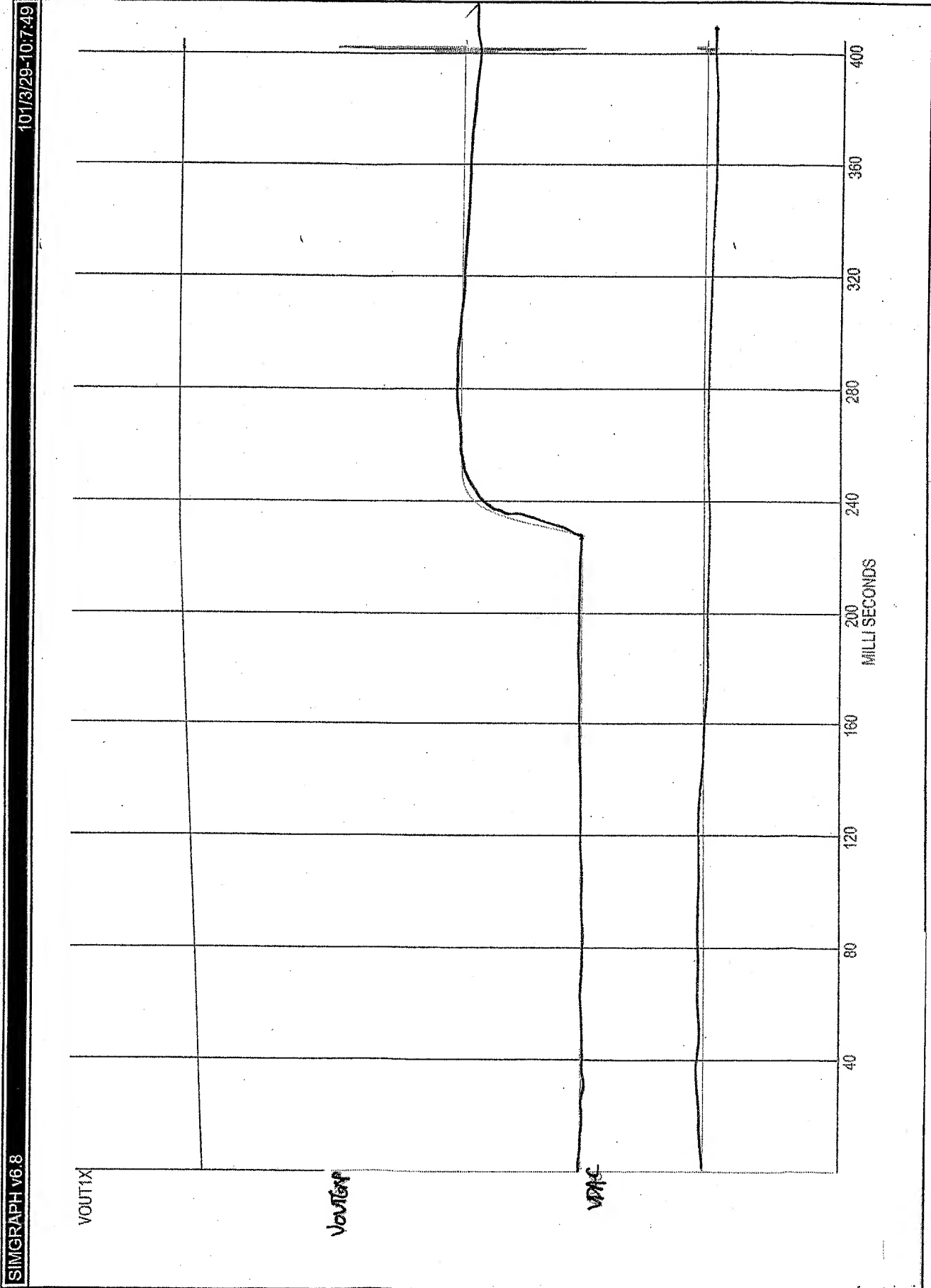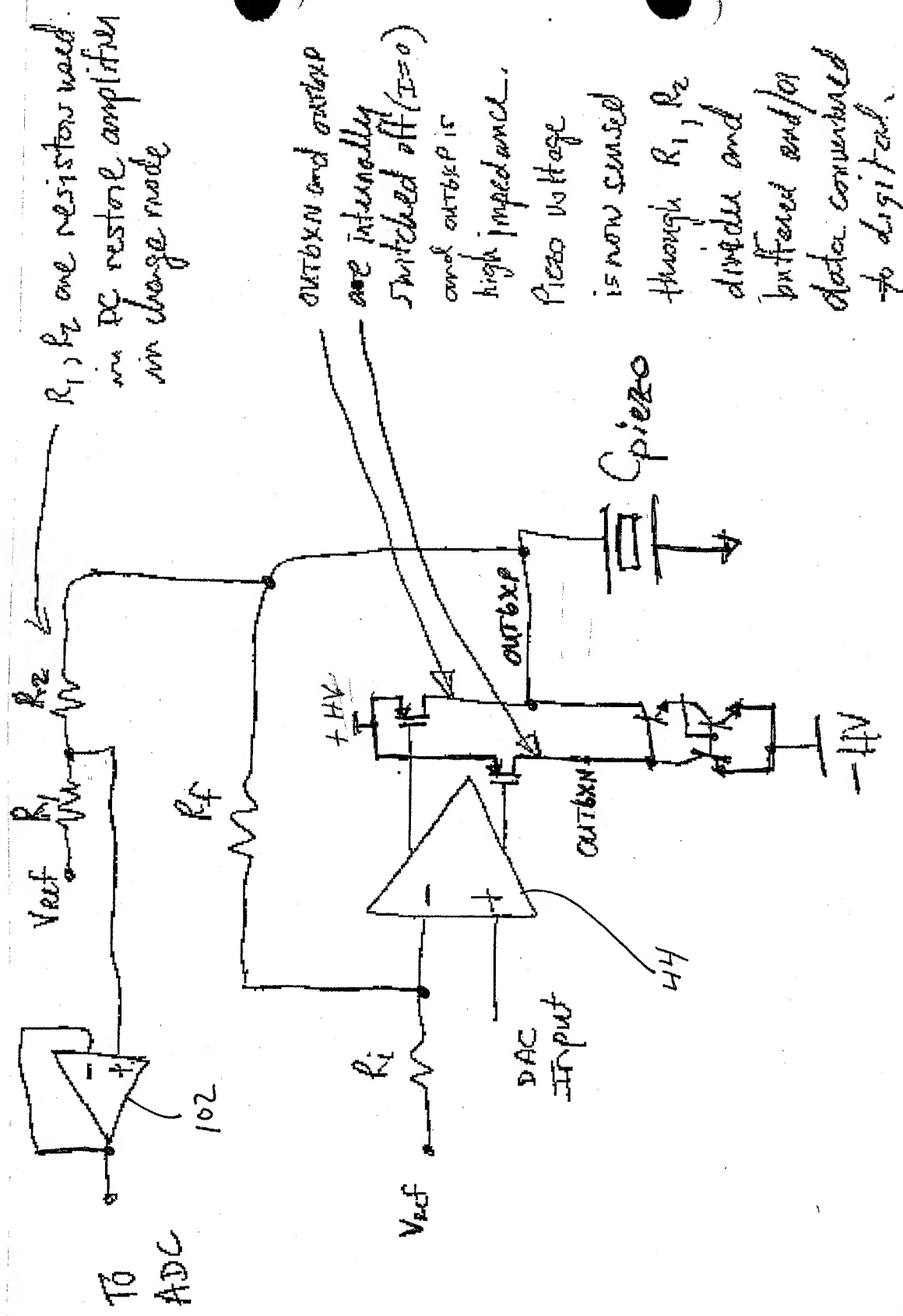
Figure 10 Voltage Mode Output Sense

TRANSIENT Response

Sammel z_t Voltage Mode - Max load - Output Sense - High Starting Voltage

DAC Input

OUTbxP

OUTiX (No real function in sense mode so it is disabled)

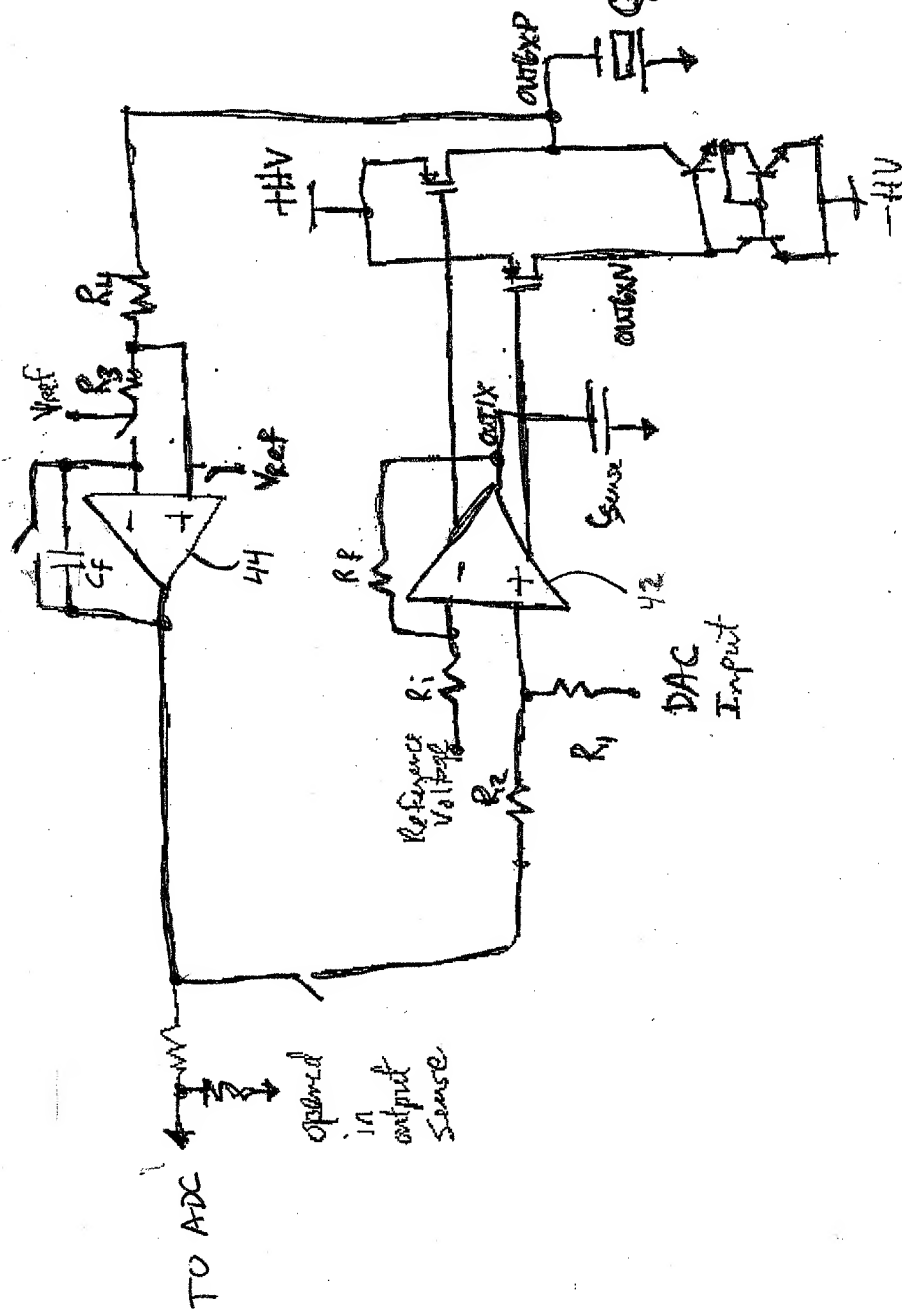Input to ADC (output of sense buffer)
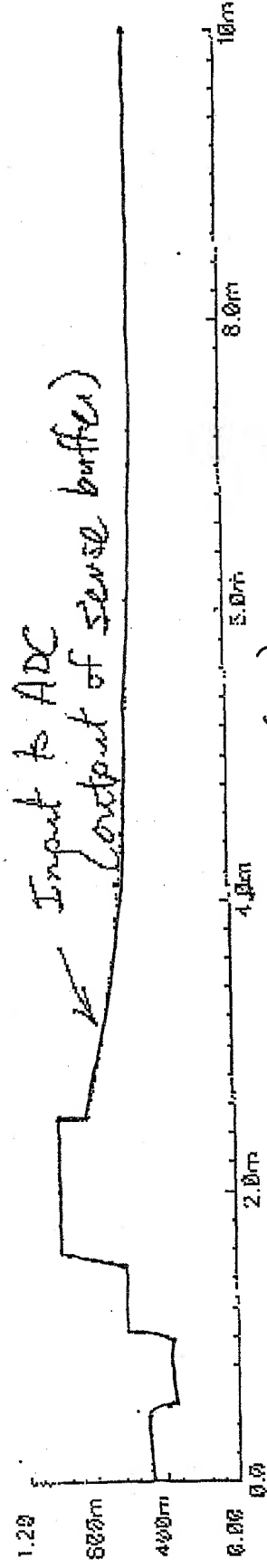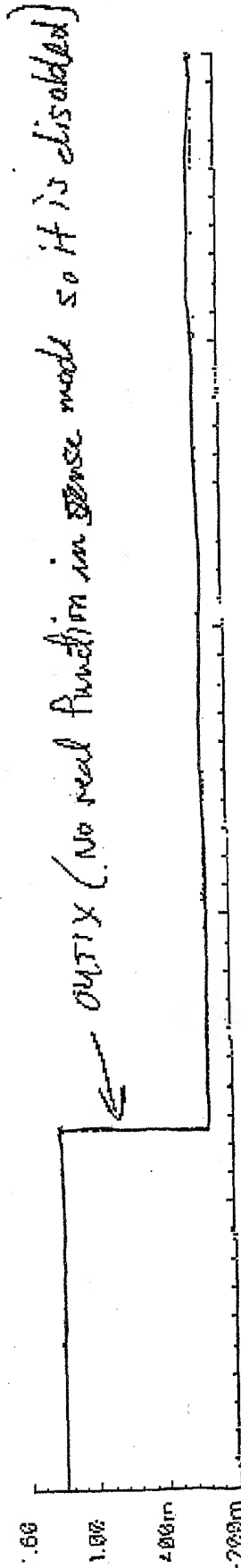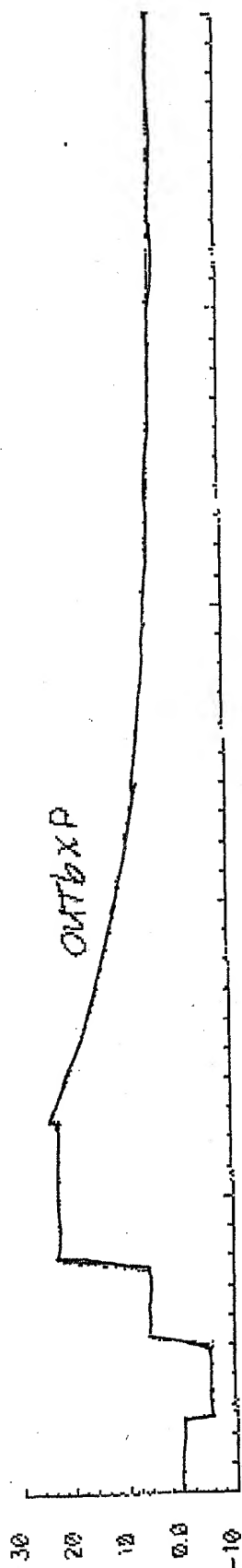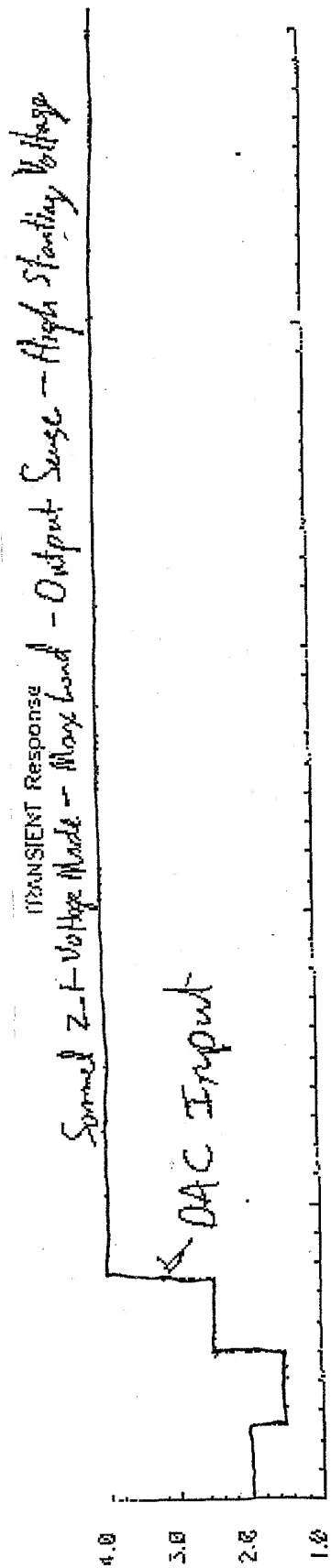
TIME (ms)

FIGURE 11

Figure 12: Charge Mode Output Sense

In charge mode output sense, the DC restore amplifier is reconfigured.

The feedback capacitor is shunted, the R_3, R_4 feedback is opened and connected to V_{ref}. The non-inverting input is opened from V_{ref} and connected to the R_3, R_4 divider.

The outputs OUTBXN and OUTBXP are made high impedance and OUTBXP can then be used through R_3, R_4 to reconfigured DC restore amplifier and sent to ADC.

TRANSIENT Response
Several 2-1 - Charge/Ripple - Output Sense - High Starting Voltage
More Load

DAC Input — 202

OUT6xP — 204

OUT1X — 206

Control signal for sense mode — 208

Input signal to ADC
(output of sensing buffer) — 210

VOLTS

TIME (ms)

FIGURE 13